REMARKS

Claim Rejections - 35 U.S.C. § 102/103

The Examiner has rejected claims 1-14 under 35 U.S.C. 102(e) as anticipated by or, in the alternative, under 35 U.S.C. 103(a) as being obvious over Mravic et al. (US Patent No. 6,083,840). It is the Examiner's position that Mravic discloses a chemical mechanical polishing method for polishing a copper layer. According to the Examiner, a silicon dioxide layer is formed over the silicon substrate. Trenches are formed within the substrate. A diffusion barrier layer is formed over the structure. Suitable compounds for the diffusion barrier layer include titanium, tantalum nitride, and tantalum silicon nitride. It is the Examiner's position that this reads upon Applicant's limitation of forming a copper diffusion barrier in the trenches. An overlayer of copper is deposited in the trenches and vias. It is Examiner's position that this reads upon Applicant's limitation of depositing copper over the copper diffusion barrier and over a top surface of the dielectric layer. Chemical mechanical polishing removes the copper overlayer to produce an integrated circuit portion (Col. 4, lines 1-18). An aqueous slurry mixture is used which consist of propanic acid, hydrogen peroxide, and fumed silica. It is the Examiner's position that silica (SiO_2) is 20% of the mixture. Additionally, it is the Examiner's position that slurry has a pH of 10.0. It is the Examiner's position that this reads on Applicant's limitation of polishing the copper with a high pH slurry. Chemical mechanical polishing is performed with a downforce of 5 psi. The Examiner does state that Mravic does not teach a method in which the copper film is polished with a slurry having a pH in such a range that a protective layer is formed over the film during polishing. The Examiner, however,

states that this limitation would be inherent in Mravic because the copper film is polished with a high pH slurry.

With respect to claims 6, 8, 9, and 10, it is the Examiner's position that the above cited dependent claims differ from Mravic by specifying various processing conditions. It is the Examiner's position that a person having ordinary skill in the art at the time of the claimed invention would have found it obvious to modify Mravic by using different processing parameters because the same were known to be cause effective variables and routine experimentation would have been expected to optimize them.

It is Applicant's understanding that Mravic fails to teach or render obvious Applicant's invention as claimed in claims 1-14 as well as new claims 28-33.

With respect to claims 1-10, Applicant claims a method of forming a copper interconnect. The method includes polishing a copper film with *"a high pH slurry having less than or equal to 10 wt% of abrasive"*.

It is Applicant's understanding that Mravic fails to disclose or render obvious polishing a copper film with a high pH slurry which has abrasive in the amount of less than or equal to 10 wt%. Mravic discloses two slurries: a bulk copper polishing slurry (Col. 5, line 14-Col. 7, line 40) and a $Cu/Ta/SiO_2$ slurry (Col. 7, line 43-Col. 8, line 39). Neither the bulk copper polishing slurry nor the $Cu/Ta/SiO_2$ slurry teaches or renders obvious polishing a copper film with a high pH slurry having an abrasive in the amount of 10% by weight.

The bulk copper polishing slurry comprises a first component which is an abrasive phase and a second component which is a liquid activator phase (Col. 5, lines 15-17). The abrasive phase includes particles and typically a base so that the pH is approximately 9-12 (Col. 5, lines 17-19). The liquid activator phase of the system contains carboxylic acid. When the abrasive phase and the liquid activator phase are mixed together, the bulk copper polishing slurry has a pH between 3 and 5 (see Table

1 and Table 2 in Col. 7). Thus, the bulk copper polishing slurry fails to teach a copper slurry with a high pH.

The Cu/Ta/SiO_2 slurry has a pH from approximately 9-11 (Col. 8, lines 1-3). The Cu/Ta/SiO_2 slurry, however, has a high particle concentration of between 15-30 wt.% and preferably between 18-25 wt.% (See Table 3).

Additionally, one of ordinary skill in the art would not be motivated to reduced the particle concentration in the Cu/Ta/SiO_2 slurry to Applicant's claimed range of less than or equal to 10 wt%, because Mravic uses the high abrasive particle concentration in his Cu/Ta/SiO2 slurry to obtain the 1:1:1 polishing ratio of copper, tantalum and SiO_2. It is to be appreciated that tantalum and silicon dioxide require high abrasive concentrations in order to polish at acceptable rates. As such, for the above mentioned reasons, it is Applicant's understanding that the cited reference fails to teach or render obvious Applicant's invention as claimed in claims 1-10. Applicant therefore respectfully requests the removal of the 35 U.S.C. § 102 and 103 rejections of claims 1-10 and seeks an early allowance of these claims.

With respect to claims 11-14, Applicant claims a method of polishing a copper film including the step of polishing the copper film with a slurry having a pH and composition such that a protective layer is formed over the copper film during polishing. As noted by the Examiner, Mravic fails to teach polishing a copper film such that a protective layer is formed over the copper film during polishing. It is the Examiner's position, however, that this would be inherent in Mravic process because he utilizes a high pH slurry. It is to be noted, however, that in order to form a protective layer on a copper film during polishing, the slurry must be in the passivation region of the Pourbiax diagram for copper (see Figure 5). In order to be in the passivation region of the Pourbiax diagram, the slurry must have a high pH (horizontal axis) and the composition of the slurry must create a slurry with the appropriate electrical potential (vertical axis). Accordingly, a slurry having a pH

between 9 and 11 as disclosed by Mravic, does not necessarily place the slurry in the passivation region of the Pourbiax diagram because the composition of the slurry may create an electrical potential which places the slurry in the immunity region of the Pourbiax diagram. Thus, contrary to the Examiner's statement, just because the Cu/Ta/SiO_2 slurry of Mravic has a high pH, does not necessitate the formation of (i.e., inherently form) a protective layer on the copper layer during polishing. As such, Mravic fails to teach or render obvious Applicant's invention as claimed in claims 11-14. Applicant therefore respectfully requests the removal of the 35 U.S.C. § 102 and 103 rejections of claim 11-14 and seeks an early allowance of these claims.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE CLAIMS

1. (Amended) A method of forming copper interconnect, comprising:

forming a dielectric layer over a substrate, the dielectric layer having trenches therein;

forming a copper diffusion barrier at least in the trenches;

depositing copper over the copper diffusion barrier and over a top surface of the dielectric layer; and

polishing the copper with a high pH slurry <u>having less than or equal to 10 wt% of abrasive.</u>

2. The method of Claim 1, wherein the dielectric layer comprises an oxide of silicon, and the copper diffusion barrier is electrically conductive.

3. The method of Claim 1, wherein the dielectric layer comprises a fluorinated oxide of silicon, and the copper diffusion barrier is selected from the group consisting of tantalum, and tantalum nitride.

4. The method of Claim 1, wherein the high pH slurry has a pH between approximately 7.5 and 12.

5. The method of Claim 4, wherein the high pH slurry has a pH between approximately 8 and 11.5.

6. The method of Claim 1, wherein the slurry contains approximately 2% to 10% by weight of SiO_2.

7. The method of Claim 1, wherein the slurry contains an oxidizer comprising $(NH_4)_2S_2O_8$.

8. The method of Claim 1, wherein polishing comprises chemical mechanical polishing with a down force of less than or equal to approximately 3.75 psi.

9. The method of Claim 1, wherein polishing comprises:

engaging the copper with a polishing pad with a down force less than or equal to 3.75 psi; and

providing a slurry flow rate of approximately 200 ccm.

10. The method of Claim 9, wherein polishing further comprises an orbital speed of approximately 310 rpm and a wafer rotational speed of approximately 10 rpm.

11. (Amended) A method of polishing a <u>copper</u> film, comprising:

polishing the copper film with a slurry having a pH and composition [in a range] such that a protective layer is formed over the copper film during polishing.

12. (Amended) The method of Claim 11, wherein [the film comprises copper and] the pH is the range of approximately 8 to 11.5.

13. The method of Claim 12, wherein the slurry comprises a precipitated SiO_2.

14. The method of Claim 13, wherein the precipitated SiO_2 comprises approximately 2 to 10 wt% of the slurry.

28. (New) A method of polishing a copper film comprising:

polishing said copper film with a slurry having a high pH and an abrasive in the amount of less than 10% by weight.

29. (New) The method of claim 28 wherein said slurry has a pH between 7.5 and 12.

30. (New) The method of claim 29 wherein said slurry has a pH between 8 and 11.5.

31. (New) The method of claim 28 wherein said slurry contains approximately 2% - 10% by weight of said abrasive.

32. (New) The method of claim 28 wherein said slurry contains approximately less than 5% by weight of said abrasive.

33. (New) A method of polishing a copper film comprising:

polishing the copper film with a slurry comprising:

an abrasive in the amount between 2-10 wt% of said slurry;

an oxidizer;

a corrosion inhibitor; and

a pH between 8 and 11.5.